REMARKS

Claims 1-47 remain in the application Further examination and reconsideration of the application, as previously amended, is hereby requested.

On Page 2 of the Office Action, the Examiner rejected claims 1-47 under 35 USC 112 1st Paragraph as containing subject matter which was not described in the specification in such a was as to reasonably convey to one skilled in the relevant art that the inventors, at the time the application was filed, had possession of the claimed invention. In particular, the Examiner noted that claims 1-47 disclose nano-porous openings in the cathode layer and the added disclosure in the specification describing Fig. 12a and 12b referring to the nano-porous openings were not disclosed in the original specification and therefore is considered new matter. Applicants respectfully traverse this rejection.

As discussed in the previous amendment, the Applicants have demonstrated that the physical structure of the product by process emitter is indeed different from that of the cited art and that the physical structure is an inherent property of the emitter after it has been subjected to the annealing process. Accordingly, the Applicants had previously amended the independent claims to include this physical structure that is an inherent property and added support in the specification. By adding the additional structure, it is believed that the Examiner's "product by process" assertion has been obviated and that based on case law and the MPEP that no new matter has been entered.

As noted in MPEP 2163.07(a), "by disclosing in a patent application a device that inherently performs a function or has a property, operates according to a theory or advantage, a patent application necessarily discloses that function, theory or advantage, even though it says nothing explicit concerning it. *The Application may be latter amended to recite the function, theory or advantage without introducing prohibited new matter.*" Support for this position is found in In re Nathan, 328 F.2d 1005, 140 USPQ 601 (CCPA 1964) and Kennecott v. Kyocera, 835 F.2d 1419, 5 USPQ.2D 1194 (Fed. Cir. 1987). In in re Nathan, the court held that an amendment to the specification which clarified the structure of the invention based on extraneous evidence discovered after the filing of the application is permissible if their original disclosure sufficiently identified the

claimed subject matter in terms of measured physical properties. (328 F.2d at 1008.) In Kennecott, the court held that since "anyone with a microscope would see the microstructure of the product", the "disclosure in a subsequent patent application of an inherent property of a product does not deprive that product of the benefit of an earlier filing date." (835 F.2d at 1423.) Accordingly, the Applicants have previously amended the specification to add the recitation of the advantage of the nano-porous openings. The paragraph starting on page 10, line 19 had been amended to include the sentence: "Examination of the annealed emitters reveals that the cathode layer has nano-porous opening on the order of less than 200 nanometers in at least one direction of length, width, or diameter." This advantage of the nano-porous openings would be readily visible to one of ordinary skill in the art when viewing the annealed emitter with an electron microscope. Therefore the nano-porous openings are an inherent property and thus no new matter has been added to the specification. Withdrawal of the rejection under 35 USC 112, 1st Paragraph is respectfully requested.

On Page 2 of the Office Action, the Examiner rejected claims 36-42 under 35 USC 112, 1st Paragraph as containing subject matter which was not described in the specification in such a was as to reasonable convey to one skilled in the relevant art that the inventors, at the time the application was filed, had possession of the claimed invention. In particular, the Examiner asserts that claims 36-42 disclose first and second chamber and sidewalls which were not disclosed in the specification. Applicants respectfully traverse this rejection.

As stated in the previous amendment, Applicants respectfully submit that the sidewalls are clearly shown in Fig. 11L and described on page 10, lines 8-13 and would be readily apparent and reasonably convey to one of ordinary skill in the art that Applicants had possession of the claimed invention. However, to further clarify the description, the Applicants previously added reference characters to Fig. 11L and the specification to make the feature of the sidewalls more explicit. The specification on page 10, lines 8-13 clearly describes the relationship of the sidewalls as shown in Fig. 11L to the emitter chamber. Removal of this objection is respectfully requested.

On Page 3 of the Office Action, the Examiner objected to the drawings as failing to comply with 37 CFR 1.84(p)(5) because Fig. 11K did not include the reference numbers 81 and 83. In the previous amendment, Applicants amended the specification to update Fig. 11L to include the reference designators 81 and 83 in the description of Fig. 11L. However, Applicants are submitting herewith a replacement page for Figs. 11K and 11L that both show the reference designators 81 and 83. Approval of the drawing change and withdrawal of the objection is respectfully requested.

On page 3 of the Office Action, the Examiner rejected claims 11, 13, and 14 under 35 USC 102(b) as being anticipated by Xia (US patent 6,034,479). Applicants respectfully traverse this rejection. As noted in the previous amendment, claims 11, 13, and 14 depend directly or indirectly on independent claim 1 and thus incorporate the limitations of claim 1. Xia is directed to a "Single Pixel Tester for Field Emission Displays" (See title, abstract and col. 3, lines 55-67.) Xia does not disclose, teach, or suggest the limitation of a "silicon-based dielectric layer" nor that "the emitter has been subjected to an annealing process to create nano-porous openings in the cathode layer" as Applicants are claiming in claims 1, as previously amended, and which is included by way of dependent limitation in claims 13 and 14. Accordingly, because "a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference," Xia does not anticipate claims 11, 13, and 14. In addition, as will be discussed below, Applicants believe independent claim 1, as previously amended, to be patentable over the art made of record. Accordingly, dependent claims 11, 13, and 14 are believed patentable based on the patentability of claim 1.

Accordingly, for the foregoing reasons, Xia does not anticipate claims 11, 13, and 14 and withdrawal of the rejection under 35 USC 102(b) is respectfully requested.

On Page 4 of the Office Action, the Examiner rejected claim 24 under 35 USC 102(b) as being anticipated by Gibson (US Patent 5,557,596). Applicants respectfully traverse this rejection.

Dependent claim 24 depends directly on independent claim 17, as previously amended, and includes all of claim 17's limitations. Accordingly, the storage device of claim 24 includes an "integrated circuit" that includes the emitter of claim 17, as previously amended, which has the limitations of a "silicon-based dielectric layer" and "wherein the emitter has been subjected to an annealing process to create nano-porous openings in the cathode layer." These limitations are not disclosed, taught or suggested by Gibson as Gibson discloses "*field* emitters ... the type that can produce electron beams that are *narrow enough* to achieve the bit density of the storage medium, and *can provide the power density* of the beam current needed for reading and writing to the medium" (see col. 3, lines 39-44). Therefore, Gibson discloses the use of "field emitters" and not a tunneling emitter with a "silicon-based dielectric layer" "subjected to an annealing process" as Applicants are claiming. Nor would it be obvious to substitute a tunneling emitter (also known as a flat (vs. tip) emitter) for the field emitter. In Gibson's application, the emitter must be capable of producing a narrow beam at a sufficient power density to read and write the medium. Conventional tunneling emitters are unable to meet this requirement while Applicants' disclosed and claimed emitters provide a power density 10-1000x (as discussed below) more than that found with prior art tunneling emitters. Thus, Applicants' annealed tunneling emitters are now comparable in power density of field emitters and allows for operation of the emitter in less stringent vacuum environments thus allowing for higher reliability, lower costs, and less complex packaging. Accordingly, Gibson does not anticipate nor suggest Applicants' claimed invention. Removal of the rejection under 35 USC 102(b) for claim 24 is respectfully requested.

On page 4 of the Office Action, the Examiner rejected claims 1-10 under 35 USC 103(a) as being unpatentable over Chuman (US Patent 6,023,124) in view of Nakatani (US Patent 6,008,576). Applicants do not understand how Nakatani (directed to a display device) is pertinent to claims 1-10 of the present invention. However, Applicants respectfully traverse the Examiner's rejection of claims 1-10 over Chuman alone or in combination with Nakatani.

In regard to claim 1, the Examiner states that claim 1 is a product by process claim and that the final product per se which must be determined in a

"product by process" claim and not the patentability of the process. The Applicants agree that it is the final product structure and not the process that determines the patentability of a product by process claim. However, as explained by the Applicants in the previous office action, the final structure of the emitter differs from that of the prior art in that the process of annealing the emitter creates a unique structure that is evidenced by nano-porous openings in the cathode layer and is repeated below. (Please see previous amendment for Exhibits, portions of which are exhibited below).

In in re Spada, 911 F.2d 705, 709, 15 USPQ.2D 1655 (Fed. Cir. 1990), the Federal Circuit concluded that the Board of Patent Appeals (PTO) was correct in requiring that an Applicant in a product-by-process claim, upon sound basis that the prima facie case has been made, to have the burden of proof *to show they are not the same structure*. The PTO suggested, and the Federal Circuit agreed, that an Applicant should provide some scientific explanation for the asserted differences between the properties of his compositions and those described by the prior art. The court went on to say that "[w]hile an inventor is not required to understand how or why an invention works, we think that the PTO was correct, in view of the apparent identity of the compositions, in requiring Spada to distinguish his compositions from those of [the prior art]." The court implied that the evidence must relate to the fundamental question of novelty of the claimed invention over the prior art otherwise evidence of unobviousness is superfluous. Id. In Spada, the court stated that the Applicant is *reasonably* required to show that his claimed composition is different from those describe by the prior art.

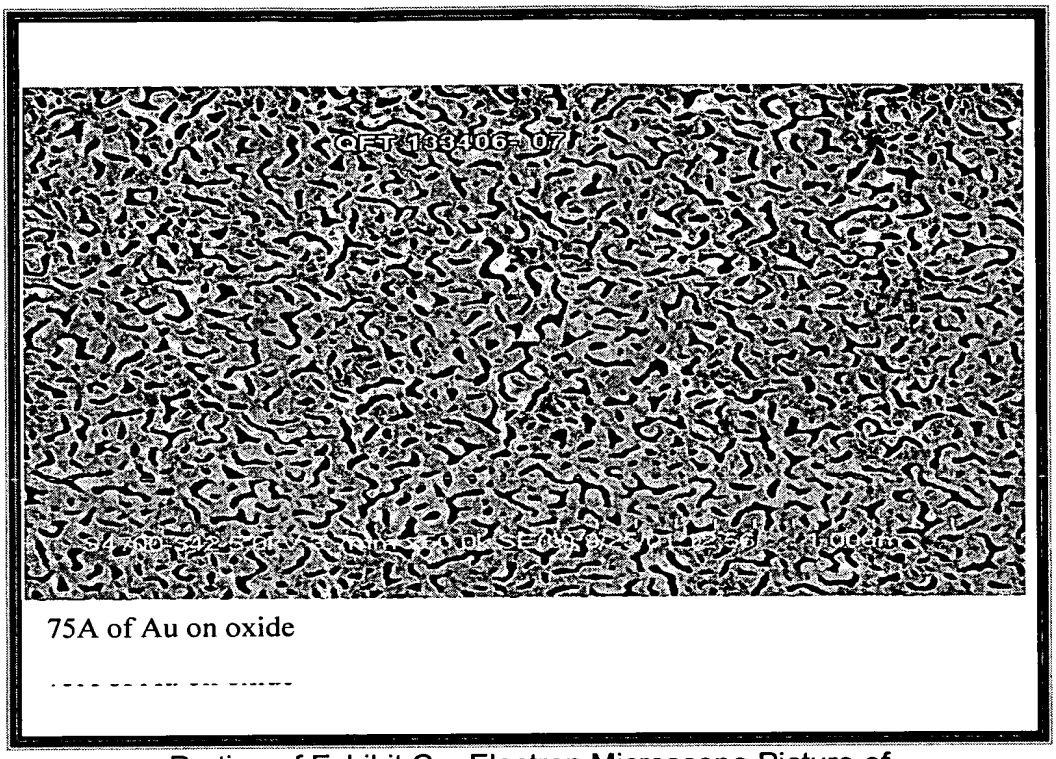
While it is well established that an Applicant for patent need not understand the theory of operation of his invention (Eames v. Andrews, 122 U.S. 40 (1887)), it appears that the Applicants are required to do so to overcome the shift in the burden of persuasion. Accordingly, Applicants have further investigated the remarkable results of their invention and now can further describe the physical changes and possible theory of operation as to why their process produces a emitter that is physically different in both the kind of structure and the degree of results obtained. Applicants believe that they have clearly shown in the disclosure how to achieve the claimed results even though at the time of filing they did not understand of the difference in structure and theory of operation for the unexpected properties. However, Applicants did detail the unexpected properties.

For instance, on page 10, lines 17-18, the Applicants state that the emitter is subjected to an annealing process to increase the amount of electron emission from the emitter. Figs. 12A and 12B are shown and described as two exemplary annealing processes. Other effects of the annealing process include increased device yields and increased operating lifetime. Noticeable physical differences include decreased resistance of the contacts of dissimilar metals which increases the current flow to the emitters.

Since filing of the application, the inventors have performed additional tests to better understand the theory of operation and the physical differences from that of the prior art. Among the differences are that:

1) The contact resistance decreases at the interface between the tunneling layer and the electron source, and at the interface between the tunneling layer and the cathode layer. This effect is typical of metal interfaces that are subjected to annealing and would likely be expected.

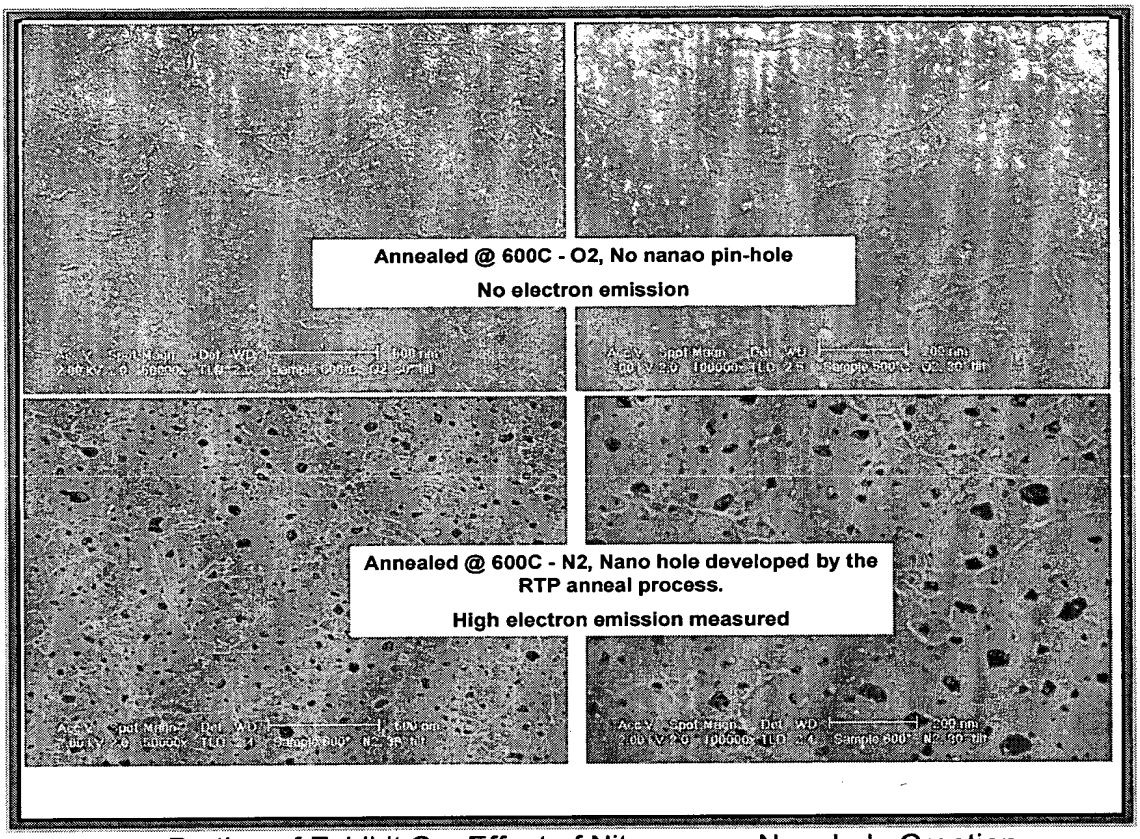
2) *Most importantly*, the top structure of the cathode layer is transformed during the annealing process to create *nano-sized porous pinholes* or openings. These openings allow the electrons that tunnel across the energy barrier to escape without losing momentum due to collisions in the cathode layer. If the cathode layer does not have openings, then the electrons that tunnel must have sufficient momentum (energy) remaining after the tunneling to escape through the thin layer of cathode material. By having openings, electrons that tunnel that have less than sufficient energy to escape the cathode layer previously can now exit through the openings. This greatly increases the number of electrons that can be emitted from the tunneling emitter. These openings also allow for photon emission because without the openings, the photons would ordinarily be absorbed into the opaque cathode layer. By allowing a wide range of tunneled electron energies to escape through the openings, the nanoholes in the cathode layer help to reduce spiking in the emission output and improves the emission stability. Below is a Figure from Exhibit C which exhibits the nano hole structure in a 75 Angstrom gold cathode layer.



Portion of Exhibit C – Electron Microscope Picture of Nanohole Structure in Gold Cathode Layer

Subsequent tests (see Exhibit C of previous amendment) have shown that when the emitter is annealed in an only oxygen or only argon environment the nano-holes are not formed. However, nanoholes are formed when annealing is performed with either an air (which contains 78% nitrogen, 21% oxygen) or a nitrogen only atmosphere. Thus, it appears that tunneling layer undergoes a transformation during annealing by introducing impurities of nitrogen into the tunneling layer. Furthermore, the cathode layer is physically changed during annealing to create a layer with nano-sized holes that allow for increased electron and photon emissions.

Below is a Figure from Exhibit C which demonstrates the results of annealing a ~70 Angstrom platinum cathode layer in O_2 in which nanoholes where not formed and annealing a ~70 Angstrom platinum cathode layer in N_2 in which the nanoholes were formed.



Portion of Exhibit C – Effect of Nitrogen on Nanohole Creation

It is evident that these differences in physical properties due to annealing the emitter lead to a novel structure different from that described in the prior art. As evidence of the novel structure, the change of the emitter due to annealing produces unexpected results in the form of increased emissions, photonic emissions, and more stable emissions which make the claimed invention unobvious over the prior art. Further evidence is the electron microscope pictures showing the nanohole formation that alters the structure of the cathode layer.

Determining whether the results are truly unexpected is addressed in the MPEP in §716.02. According to MPEP 716.02, a greater than expected result is an evidentiary factor pertinent to the legal conclusion of obviousness. Evidence of a greater than expected result may be shown by demonstrating an effect which is greater than the sum of each of the effects taken separately. The evidence should establish that the differences in result are in fact unexpected and unobvious and of both statistical and practical significance.

Following are exemplary test results from the chart in Exhibit B of the previous amendment for an emitter with a Silicon Carbon (SiC) tunneling layer of 500 angstroms thickness and a 35 micron diameter emitter surface

:~ 120 nA peak emission, average emission of 5nA.

The current density of the emitter can be calculated based on the emitter size and the emission current. The emitter size reported is the diameter of the emitter in microns. The emission current reported (I_e) is in units of nanoamperes. Thus the current density in terms of Amps/cm^2 is:

Current density in Amps/cm^2 = I_e Amps/(10000 cm^2/m^2*3.14*(1/2*emitter size in meters)^2)

For the 35um SiC with 120nA, this emitter has a current density of:
120E-9 Amps/(10000*3.14*(1/2*35E-6)^2 = 0.012 Amps/cm^2

During typical operation, these emitters will be pulsed with extremely small duty cycles, thus allowing for increased emissions due to less localized heating. By having less localized heating, the leakage current is reduced and there is less vibrations in the materials of the tunneling and cathode layers. These lower vibrations will allow more electrons to escape rather than be deflected or adsorbed. It is expected that emission currents from this low duty-cycle pulsed operation will be substantially higher, such as two to four times that measured. Therefore, these results support the claimed ranges of Applicants invention of providing an emission current of at least 10 mAmps/cm^2 which is an order of magnitude greater than that accomplished by the prior art devices (which report up to 1mAmps/cm^2). These are truly unexpected results of both statistical and practical significance (see MPEP 716.02(b)), principally created by the nanohole structure in the cathode layer and lowering of the tunneling resistance created by the annealing process. Both the emission results and the structural changes to the emitter due to the annealing process are evidence of unexpected results and evidence of non-obviousness over the prior art. As noted by MPEP 716.02(d), the

"objective evidence of nonobviousness must be commensurate in scope with the claims which the evidence is offered to support."

Applicants believe that they have demonstrated the non-obviousness of the claimed emitter and that the subjecting the claimed emitter to an annealing process creates both statistically and practical significant results which where previously unknown to those skilled in the art and therefore not disclosed, taught, or suggested by the art made of record. Thus, Applicants have reasonably shown that the claimed combination is different from that of the prior art. This argument and evidence should be sufficient to overcome the shift in the burden of persuasion due to the Examiner's assertion of the "product by process" argument.

Further, the Applicants have demonstrated that the physical structure of the product by process emitter is indeed different from that of the cited art and that the physical structure is an inherent property of the emitter after it has been subjected to the annealing process. Accordingly, the Applicants have previously amended the independent claims to include this physical structure that is an inherent property and added support in the specification. By adding the additional structure, it is believed that the Examiner's "product by process" assertion has been obviated. The Applicants believe that based on case law and the MPEP that no new matter has been entered as was discussed previously under the 35 USC 112 1st paragraph rejection.

Further in regards to claims 4-6, the Examiner states that Chuman discloses an emission device that has an emission current greater than 1×10^{-3} Amps/cm^2 and that it would be obvious . . . to modify Chuman to include an emission current greater than 1×10^{-3} Amps/cm^2 to provide high luminance. Applicants respectfully traverse the Examiner's assertion of obviousness. The Examiner has failed to state how to modify Chuman's emitter to get higher density or how Chuman itself discloses, teaches, or suggest a higher current density than 1mA/cm^2. Thus, the Examiner's assertion is a mere conclusion without factual evidence or reason

As discussed previously, the claimed emission is expressed in terms of current density per area. It would not be obvious to increase the emissions of Chuman, as one could not increase the current density per area by simply making the emitter larger. The Applicants have increased the emission current density by subjecting the emitter to an annealing process that changes the structure of the

emitter by creating nano-porous openings, thus allowing for higher emissions. Indeed, Chuman shows in its Fig. 2a a maximum current density output of about 1 x 10^{-3} Amps/cm^2 by manipulating *the tunneling layer thickness*. The Applicants have been able to far exceed this disclosed current density by at least one order of magnitude (a factor of 10X). In making the combination obvious, the Examiner does not disclose how one skilled in the art would increase the current density nor does Chuman disclose, teach, or suggest a current density greater than 1 x 10^{-3} Amps/cm^2. If the Examiner continues to assert this rejection, the Applicants respectfully request the Examiner to provide an affidavit describing how to do so or to supply a reference that teaches Applicants' structure, as previously amended.

In contrast, the Applicants have disclosed and claimed how to increase the current density by using an annealing process and its ability to respectively alter the structure of the emitter by lowering the tunneling layer resistance, reducing ohmic contacts, and most importantly, creating nano-porous openings in the cathode layer. It is through the application of the annealing process that these unexpected results have been obtained. None of these changes in structure have been disclosed, taught, or suggested by the proposed combination or other art made of record. Further evidence of the state of the art in electron emission density is found in Kusunoki on page 1667 (bottom of left column) wherein the emission current to date (8/20/99 when manuscript received) is 50 x 10^{-6} Amps/cm^2. The desire for at least 1 mA/cm^2 is noted. In Fig. 5, Kusunoki only discloses an emission density of up to this 1mA/cm^2 limit, i.e. the same as Chuman. Accordingly, the rejection under 35 USC 103(a) and allowance for claims 2-10 are respectfully requested.

On page 6 of the Office Action, the Examiner rejected claim 12 under 35 USC 103(a) as being unpatentable over Xia in view of Gibson. Claim 12 is dependent upon claim 11 which is dependent upon claim 1. Claim 12 is believe patentable based at least on the patentability of claim 1 as earlier discussed. Claim 12 is believed separately patentable. First, Xia is directed to a single pixel tester for "field emission displays" and thus does not even remotely suggest let alone teach or disclose its use as a storage device. Second, Xia discloses a "field emission tip emitter," the same type of emitter as that disclosed in Gibson. Claim

1, as previously amended, upon which claim 12 indirectly depends, is claiming a "tunneling emitter" with "a silicon based dielectric layer disposed" on an "electron supply" and a "cathode layer disposed on the silicon based dielectric layer" that has been subjected to an "annealing process" to "create nano-porous opening in the cathode layer." These limitations are not disclosed, taught, or suggested by Xia or Gibson alone or in combination. Accordingly, removal of the rejection and allowance of claim 12 is respectfully requested.

On Page 7 of the Office Action, the Examiner rejected claims 15, and 16 under 103(a) as being unpatentable over Chuman in view of Gibson. Claim 15 has been previously amended to include the limitation wherein the emitter includes "a cathode layer disposed on the silicon-based dielectric layer" and that the emitter has been subjected to an annealing process "to create nano-porous openings in the cathode layer." The Applicant has explained previously for claim 1 why the annealing process provides unexpected and non-obvious results thereby indicating that the structure of the emitter is different than that of the prior art. However, the Applicants have amended the claim to include the limitation of nano-porous openings that are created by the annealing process to provide additional structural limitation thereby obviating the product by process argument asserted by the Examiner. These limitations are not disclosed, taught, or suggested by Chuman or Gibson alone or in combination. Accordingly, removal of the rejection under 35 USC 103(a) and allowance of claims 15 and 16 are respectfully requested.

On page 8 of the Office Action, the Examiner rejected claims 17-22 and 25 under 35 USC 103(a) as being unpatentable over Chuman in view of Moyer (US patent 5,473,218) and Nakatani. Applicants have previously amended claim 17 to include the limitation of where the emitter has been subjected to an annealing process "to create nano-porous openings in the cathode layer." As discussed previously with respect to claim 1, this limitation is not disclosed, taught, or suggested by Chuman or Moyer alone or in combination with Nakatani.

Further with respect to claims 19, the Examiner states that it would have been obvious to modify Chuman to achieve an emission rate of 0.01 Amps/cm^2. However, this is just a conclusionary statement without any reasoning or basis to

support it. Chuman only discloses being able to achieve a 0.001Amp/cm^2 emitter by varying the dielectric thickness. Since the current density is expressed in terms of current per surface area, merely making the emitter bigger does not increase the current density. Applicants are able to increase the current density by using the annealing process to create the nano-porous openings which allow tunneled electrons to pass through the cathode layer without losing momentum. Accordingly, claim 19 is believed separately patentable over Chuman and Moyer.

Claims 18, 20, 21 and 22 depend directly on claim 17 and are believed at least patentable based on the patentability of claim 17.

Claim 25 includes the additional limitation of a "focusing device for converging the emissions from the emitter." This limitation is not disclosed, taught or suggested by Xia. At most, Xia discloses an extraction gate or grid structure 15 (Fig. 1 and col. 1, lines 36-37). This extraction grid collects stray electrons but is not used as "a focusing device for converging the emission from the emitter" as Applicants are claiming. On page 13, the Examiner states that Nakatami discloses a lens for focusing light with a transparent layer 8 shown in Fig. 2. However, element 8 is described as a fluorescent layer upon which the electrons impinge causing excitation light to be emitted (see Nakatami Col. 9, lines 34-41). This fluorescent layer is not a "focusing device for converging the emissions from the emitter" as Applicant is claiming. According, claim 25 is believed patentable over the art made of record.

Removal of the rejection under 35 USC 103(a) and allowance for claims 17-22, and 25 are respectfully requested.

On page 11 of the Office Action, the Examiner rejected claims 26-28 under 35 USC 103(a) as being unpatentable over Chuman, Moyer, and Nakatami as applied to claims 17 and 25 above. and further in view of Xia. Claims 26-28 depend directly or indirectly on claim 25 and are deemed patentable based at least on the patentability of parent claim 25 as describe above. Removal of this rejection under 35 USC 103(a) and allowance of claims 26-28 is respectfully requested.

On Page 11 of the Office Action, the Examiner rejected claims 29-35 and 43-47 under 35 USC 103(a) as being unpatentable over Chuman and Moyer and

Huang (US Patent 5, 702,281). Applicants have previously amended claim 29 and claim 43 to include the limitation of the cathode layer having "nano-porous openings" similar to that describe above for claims 1 and 17. Applicants believe this additional structural limitation obviates the "product-by-process" assertion made by the Examiner and differentiates the claim over the art made of record. Claims 30-35 depend on claim 29 and are believed patentable at least on the patentability of claim 29. Claims 44-47 depend on 43 and are believed patentable at least on the patentability of claim 43. Removal of the rejection under 35 USC 103(a) and allowance of claims 29-35 and 43-47 is respectfully requested.

Applicants believe their claims as previously amended are patentable over the art of record, and that those prior amendments were made within the scope of a search properly conducted under the provisions of MPEP 904.02. Accordingly, claims 1-47 are deemed to be in condition for allowance, and such allowance is respectfully requested.

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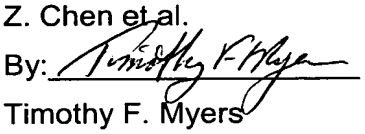
By: 
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